

SECTION 9

STANDBY DIESEL ENGINE DRIVEN GENERATOR WITH WEATHERPROOF ENCLOSURE

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SECTION 9

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9.1 GENERAL

9.11 SCOPE OF WORK

- A. Furnish all labor, materials, equipment and incidentals required to install, put into operation, and field test the weatherproof diesel engine driven generator unit and appurtenances as required by the City of Leesburg.
- B. These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the application. It is, however, intended to cover the furnishing, the shop testing, and delivery and complete installation and field testing, of all materials, equipment and appurtenances for the complete units as herein specified, whether specifically mentioned in these Specifications or not.
- C. For all units there shall be furnished and installed all necessary and desirable accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. This installation shall incorporate the highest standards for the type of service shown on the Drawings. The CONTRACTOR is responsible for field testing of the entire installation and instruction of the regular operating personnel in the care, operation and maintenance of all equipment.
- D. All standby generator sets to be utilized in the City of Leesburg utility system shall conform to these specifications and shall be subject to approval of the Environmental Services Department.

9.12 DESCRIPTION OF SYSTEMS

- A. The engine-generator set shall be mounted as shown on the Drawings and shall be arranged for automatic starting and stopping, and load transfer upon failure of the normal source of power. The unit controls shall provide for automatic exercising on a weekly basis.

9.13 QUALIFICATIONS

- A. The engine-generator set shall be the UL2200 listed standard product, as modified by these specifications, of a MANUFACTURER regularly engaged in the production of this type of equipment. The unit to be furnished shall be of proven ability and shall be designed, constructed, and installed in accordance with best practices and methods. To qualify as a MANUFACTURER, the engine must be the principal item manufactured and the completed engine generator set shall be supplied by the MANUFACTURER's authorized distributor only. The distributor shall have a minimum of ten (10) years experience in the field of power generation.
- B. It is the intent of this specification to secure an emergency generator system that has been prototype tested, factory built, production tested, site tested and of the latest commercial design, together with all accessories necessary for a complete installation as shown on the plans and drawings, and specifications herein. The equipment supplied and installed shall meet the requirements of the NEC, along with all applicable local codes and regulations. All equipment shall be new, of

current production of a national firm which manufactures the engine/generator and controls, transfer switch and switchgear, and assembles the emergency generator system as a matched unit so that there is one-source responsibility for warranty, parts, and service through a local representative with factory-trained servicemen.

- C. The unit must be of such physical dimensions as to make a good installation in the opinion of the Director of Environmental Services, in the space provided as indicated on the Drawings.
- D. The unit shall be assembled in the U.S. with over 50% of the components such as the engine, generator, auxiliary equipment, etc., manufactured in the U.S. by a MANUFACTURER currently engaged in the production of such equipment.
- E. The unit shall be shipped to the jobsite by an authorized engine dealer having a parts and service facility within a 100 mile radius of the jobsite. In addition, and in order not to penalize the OWNER for unnecessary or prolonged periods of time for service or repairs to the emergency system, the bidding generator set supplier must have no less than eighty percent (80%) of all engine replacement parts locally available at all times. Certified proof of this requirement shall be furnished to the City upon submittal of construction plans.
- F. All materials and parts comprising the units shall be new and unused, of current manufacture, and of the highest grade, free from all defects or imperfections. Workmanship shall conform to the best modern practices. Only new and current models will be considered. The units offered under these Specifications shall be the product of a firm regularly engaged in the production of engine-generator equipment and shall meet the requirements of the Specifications set forth herein. Major exceptions to these Specifications will be considered sufficient cause for rejection of the machines.
- G. The Engine/Generator Unit shall be as manufactured by Cummins Power Generation, Caterpillar, or Detroit Diesel.

9.14 SUBMITTALS

- A. Submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied, schematic wiring diagrams, dimensional drawings, and interconnection diagrams identifying by terminal number each required for interconnection between the generator set, the transfer switch, and the switchgear panels included elsewhere in these specifications.
- B. The Developer shall submit to the Director of Environmental Services for review in accordance with other sections, complete sets of installation drawings, schematics, and wiring diagrams which shall show details of installation and connections to the work of other Sections, including foundation drawings showing location and size of foundation bolts for the spring type vibration isolators and brochures covering each item of equipment.
- C. In the event that it is impossible to conform with certain details of the Specifications due to different manufacturing techniques, describe completely all nonconforming aspects.
- D. The submittal data for each engine/generator set and weatherproof enclosure shall include, but not necessarily be limited to, the following:

1. Installation drawings showing plan and elevations of the complete generator unit; foundation plan; exhaust silencer; starting battery; battery charger; weatherproof enclosure and base mounted fuel tank.
2. Engine Data:
 - a. MANUFACTURER
 - b. MODEL
 - c. Number of cylinders
 - d. RPM
 - e. Bore x stroke
 - f. BMEP at full rated load
 - g. Piston speed, FPM
 - h. Make and model and descriptive literature of electric governor (where required)
 - i. Fuel consumption rate curves at various loads
 - j. Engine continuous pump drive duty rating (without fan) HP
 - k. Gross engine horsepower to produce generator standby rating (including fan and all parasitic loads) HP
3. Generator Data:
 - a. MANUFACTURER
 - b. Model
 - c. Rated KVA
 - d. Rated SKVA
 - e. Rated kw
 - f. Voltage
 - g. Temperature rise above 40 degree C ambient
 - 1) Stator by thermometer
 - 2) Field by resistance
 - 3) Class of insulation
 - h. Generator efficiency including excitation losses and at 80 percent power factor.
 - 1) Full load
 - 2) 3/4 load
 - 3) 1/2 Load
4. Generator Unit Control Data:
 - a. Actual electrical diagrams including schematic diagrams, and interconnection wiring diagrams for all equipment to be provided. Standard preprinted sheets are not acceptable.
 - b. Legends for all devices on all diagrams.
 - c. Sequence of operation explanations for all portions of all schematic wiring diagrams.
5. Engine/Generator Unit and Weatherproof Enclosure: Dimensional data shall be given for the Engine/Generator set and for the weatherproof enclosure.
 - a. Weight of skid mounted unit
 - b. Overall length
 - c. Overall width
 - d. Overall height

- e. Exhaust pipe size
 - f. CFM of air required for combustion and ventilation
 - g. Heat rejected to jacket water and lubricating oil BTU/hr.
 - h. Heat rejected to room by engine and generator BTU/hr.
 - i. Weatherproof enclosure details and certification of manufacturing method per specifications.
 - j. Base fuel tank, venting, fuel connection points and fill cap location.
 - k. Data on all miscellaneous items supplied.
6. Optional System Service Contract:
- a. Equipment Supplier Company
Name
Address
City/State
Phone Number
 - b. Attach the number of copies required of System Service Contract to submittal.
7. Furnish the number of copies required of the MANUFACTURER'S certified shop test record of the complete engine driven generator unit.
8. Warranty information.
- E. Submit to the Director of Environmental Services operating and maintenance data.
- F. Submit to the Director of Environmental Services the equipment MANUFACTURER'S Certificate of Installation, Testing, and Instruction.
- G. Submit to the Director of Environmental Services the written warranty as required in Paragraph 3.06 below.

9.15 TESTING

To assure that the equipment has been designed and built to the highest reliability and quality standards, the manufacturer and local representative shall be responsible for three separate tests: design prototype tests, final production tests, and site tests.

- A. Design Prototype Tests: Components of the emergency system such as the engine/generator set, transfer switch, and accessories shall not be subjected to prototype tests since the tests are potentially damaging. Rather, similar design prototypes and preproduction models, which will not be sold, shall have been used for the following tests. Prototype test programs shall include the requirements of NFPA 110 and the following:
- 1. Maximum power (KW).
 - 2. Maximum motor starting (KVA) instantaneous voltage dip.
 - 3. Alternator temperature rise by embedded thermocouple and by resistance method per NEMA MG1-2240 and 16.40.
 - 4. Governor speed regulation under steady-state and transient conditions.
 - 5. Voltage regulation and generator transient response.
 - 6. Fuel consumption at 1/4, 1/2, 3/4, and full load.
 - 7. Harmonic analysis, voltage waveform deviation, and telephone influence

- factor.
 8. Three-phase short circuit tests.
 9. Alternator cooling air flow.
 10. Torsional analysis testing to verify that the generator set is free of harmful torsional stresses.
 11. Endurance testing.
- B. Final Production Tests: Each generator set shall be tested under varying loads with guards and exhaust system in place. Tests shall include:
1. Single-step load pickup.
 2. Transient and steady-state governing.
 3. Safety shutdown device testing.
 4. Voltage regulation.
 5. Rated power.
 6. Maximum power.
 7. Upon request, arrangements to either witness this test will be made, or a certified test record will be sent prior to shipment.
- C. Site Tests: An installation check, start-up and building load test shall be performed by the manufacturer's local representative. The Director of Environmental Services, regular operators, and the maintenance staff shall be notified of the time and date of the site test. The tests shall include:
1. Fuel, lubricating oil, an antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
 2. Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery charger, generator strip heaters, remote annunciator, etc.
 3. Start-up under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage, and phase rotation.
 4. Automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load, and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator voltage, amperes, and frequency shall be monitored throughout the test. An external load bank shall be connected to the system if sufficient building load is unavailable to load the generator to the nameplate KW rating.

9.16 SPECIAL TOOLS AND SPARE PARTS

- A. The MANUFACTURER shall furnish two (2) complete spare replacement sets of all filter elements required for the generator unit.

9.2 PRODUCTS

9.21 RATINGS

- A. The standby rating of the generator set shall not exceed the MANUFACTURER's

published prime rating by more than 10%. The gross engine horsepower required to produce the standby rating shall not exceed the MANUFACTURER's published continuous duty rating by more than 150 percent. Continuous duty rating shall be as defined in BS649 or DIN6270 but in no case shall it exceed the MANUFACTURER's published continuous duty rating for the engine as used in continuous rated pump drive applications. The gross engine horsepower required for the generator set standby rating described above shall include all parasitic demands such as generator inefficiencies, fuel pumps, water pumps, radiator fan (for fan cooled models) and all accessories necessary to the unit's proper operation while operating at rated load and at a rotative speed not to exceed 1800 rpm.

- B. The diesel engine driven generator set shall be capable of producing the specified standby kw rating for continuous electrical service during interruption of the normal utility source and shall be certified to this effect by the MANUFACTURER for the actual unit supplied.
- C. The Diesel Engine/Generator Unit shall be rated for 277/480 volts, 3-Phase, 60 Hertz at 0.8 power factor with fan. The engine/generator set shall be suitable for starting two (2) submersible pump motors sequentially with 5 KVA of miscellaneous load on line. Manufacturer shall certify this in writing. Obtaining a motor starting KVA for each pump motor is the responsibility of the Engineer.

9.22 ENGINES

- A. The engine shall be full compression ignition, four cycle, single acting, solid injection engines, either vertical or "V" type. Speed shall not exceed 1800 revolutions per minute at normal full load operation. Multi block engines are not allowed. The engine governor shall be electronic type with a +/- 0.5 percent accuracy. Governor shall be by Cummins EFC, Woodward, or Barber Coleman.
- B. The engine shall be capable of satisfactory performance on No. 2 fuel oil (ASTM Designation D396). Diesel engines requiring a premium fuel will not be considered.
- C. The engine shall be capable of operating at light loads for extended periods of time and shall provide a means to reduce carbonization. Periodic cleaning of exhaust ports shall not be required.
- D. The engine shall be equipped with fuel filters, lube oil filters, intake air filters, lube oil cooler, fuel transfer pump, fuel priming pump, service meter, engine driven water pump, and unit mounted instruments. Unit mounted instruments shall include a fuel pressure gauge, water temperature gauge, and lubrication oil pressure gauge. The engine shall be provided with low oil pressure, high water temperature, low coolant level and overspeed safety shutdowns of the manual reset type. Additional instruments and safety shutdowns shall be provided as noted herein.
- E. Injection pumps and injection valves shall be a type not requiring adjustment in service and shall be of a design allowing quick replacement by ordinary mechanics without special diesel experience. The engines shall have an individual mechanical injection pump and injection valve for each cylinder, any one of which may be removed and replaced from parts stock. Fuel injection pumps shall be positive action, constant-stroke pumps, activated by a cam driven by gears from the engine crankshaft. Fuel lines between injection pumps and valves shall be of heavy seamless tubing.

- F. The fuel system shall be equipped with fuel filters having replaceable elements. Filter elements shall be easily removable from their housing for replacing without breaking any fuel line connections, or disturbing the fuel pump, or any other part of the engine. All fuel filters shall be conveniently located in one accessible housing, ahead of the injection pumps so that the fuel will have been thoroughly filtered before it reaches the pump. No screens or filters requiring cleaning or replacement shall be used in the injection pump or injection valve assemblies. The engines shall be equipped with a built-in gear-type, engine-driven fuel transfer pump, capable of supplying fuel through the filters to the injection pump at constant pressure.
- G. In addition to the standard fuel filters provided by the engine MANUFACTURER, there shall also be installed a primary fuel filter and a water separator in the fuel inlet line to the engine.
- H. The engine shall be provided with removable wet-type cylinder liners of close grained alloy iron, heat treated for proper hardness as required for maximum liner life. The cylinder block shall be a one piece stress relieved gray iron casting.
- I. The engine shall have a gear-type lubricating oil pump for supplying oil under pressure to main bearings, crank pin bearings, pistons, piston pins, timing gears, camshaft bearings, valve rocker mechanism and governor. Effective lubricating oil filters shall be provided and so located and connected that all oil being circulated is continuously filtered and cleaned. Filters shall be accessible, easily removed and cleaned and shall be equipped with a spring-loaded by-pass valve as an insurance against stopping of lubricating oil circulation in the event the filters become clogged. The engine shall have a suitable water cooled lubricating oil cooler.
- J. The engine shall be provided with one or more engine mounted dry type air cleaners of sufficient capacity to protect effectively the working parts of the engine from dust and grit.
- K. During each initial start of the engine, a system shall be provided to pre-lube at low idle speed. When the internal oil pressure reaches a predetermined safe value, the engine will then increase to generator set operation speed.
- L. Mounting: The unit shall be mounted on a structural steel sub-base and shall be provided with spring type vibration isolators.

9.23 COOLING SYSTEMS

- A. The engine shall be furnished with a unit mounted radiator-type cooling system having sufficient capacity for cooling the engine when the diesel generator set is delivering full rated load in an ambient temperature not to exceed 122 degrees F. The engine shall be provided with a thermostatic valve placed in the jacket water outlet between the engine and the cooling source. This valve shall maintain the proper jacket water temperature under all load conditions. Total air restriction from the radiator shall not exceed 0.5 inches of water at both inlet and outlet. A flexible connecting section shall be provided between the radiator and discharge louver frame.
- B. Closed circuit jacket water systems shall be treated with a rust inhibitor as recommended by the engine MANUFACTURER.
- C. Provide one (1) or two (2) unit mounted thermal circulation type water heaters

incorporating a thermostatic switch shall be furnished to maintain engine jacket water at minimum of 70 degrees F. The heaters shall be 120 volt, single phase, 60 Hertz, size as required to achieve above noted ambient.

- D. The expansion tank of the radiator shall be fitted with a low water level switch and wired into the safety shutdown system of the unit.
- B. All fuel piping shall be installed in containment piping.

9.24 GENERATOR, EXCITER AND ACCESSORIES

- A. Rating: The generator shall be rated 0.8 p.f., 1800 RPM 3 phase, 60 Hertz, 277/480 volts, 4 leads, with a maximum temperature rise of 105 degrees C (both armature and field) by resistance at full rated load in ambient air of 40 degrees C. The generator shall conform to NEMA Standard MG-1. The generator shall be oversized to allow starting 2 motors (Code letter to be provided by the Contractor) across the line, sequentially, with 5 KVA of miscellaneous load on line.
- B. Performance: The instantaneous voltage dip shall not exceed 20 percent of rated voltage when full load, at rated power factor, is suddenly applied. Recovery of stable operation shall occur within 5 seconds. Steady state modulation shall not exceed +1/2 percent.
- C. Construction:
 - 1. The generator and exciter shall be drip proof, with split sleeve, or ball race bearings. A shaft-mounted brushless exciter shall be a part of the assembly. The stator core shall be built up of high grade silicon steel laminations precision punched, and individually insulated. Armature lamination followers and frame ribs shall be welded integral with the frames for support of the stator core. A directional blower shall be mounted on the unit to draw cooling air from the exciter and over the rotor poles and through louvered openings on the opposite end.
 - 2. The exciter shall be a fast response type, with a rotating 3-phase full-wave bridge. The exciter shall have a low time constant and large capacity to minimize voltage transients under severe load changes.
 - 3. Generator stator and exciter stator windings shall be a full Class H insulated system vacuum impregnated with epoxy resin which after curing shall have additional treatment of epoxy for resistance to an environment of moisture and salt air. Generator coils shall be random or machine wound, and precision made, with turn-to-turn and ground insulation of glass yard and mica materials. The average di-electric strength for the form wound coils of the ground and end turn insulation shall not be less than 400 volts per mil. Spacers shall be tightly secured between end turns, and the end turn assembly securely lashed to the support rings.
 - 4. Generator rotor poles shall be built up of individually insulated silicon steel punchings. Poles shall be wound and bonded with high strength epoxy resin. Cage connections to the amortisseur rings shall be brazed for strong construction and permanent electrical characteristics. Each pole shall be securely bolted to the rotor shaft with bolts sized for the centrifugal forces on the rotor. Generator windings shall be braced for full line to ground fault currents, with solidly grounded neutral system.

D. Accessories and Attachments

1. Low Voltage Terminal Boxes: The generator shall have separate AC and DC low voltage terminal boxes with suitably numbered terminal strip for required connections.
2. All required P.T.'s, C.T.'s and protective relays shall be supplied by the engine-generator MANUFACTURER as required.
3. Space Heaters: Space heaters shall be installed on the generator frame to maintain temperature of the entire generator above the dew point while not in use. Power supply shall be 120 volts single phase. Heaters will be automatically disconnected when engine starts. The magnetic starter for the heaters shall be mounted in the terminal box. Furnishing and installation of control and starter to be by engine/generator supplier.

E. Generator Associated Controls:

1. Voltage Regulator:
 - a. The generator MANUFACTURER shall furnish a hermetically sealed, silicon controlled rectifier type voltage regulator employing a zener reference with a +1 percent regulation for the generator. The regulator shall include 3-phase voltage sensing, automatic short circuit protection and shall include automatic under frequency protection to allow the generator to operate at no load at less than synchronous speed for engine start-up and shutdown procedures. Switches and/or fuses shall not be used to provide this protection. An over-voltage sensing module with manual reset shall be furnished with the regulator. A volts per Hz., sensing module shall be provided as part of the regulation system.
 - b. A voltage adjustment rheostat for 5 percent voltage adjustment on the unit shall be provided.
 - c. High voltage step-down potential transformers shall be provided for the voltage regulator power input and sensing circuits if required.
2. Sustained Short Circuit: A permanent magnetic exciter shall be provided on the unit for sustaining a current of 300 percent during a short circuit, permitting the generator breaker to trip on overload. To prevent possible overheating of the armature windings, appropriate relaying shall be supplied to limit the fault to ten seconds. All current transformers required shall be supplied by the switchgear MANUFACTURER.

9.25 WEATHER-PROTECTIVE ENCLOSURE

- A. The intent of this Specification is to provide the City of Leesburg with a weatherproof sound attenuated generator set enclosure complete in every detail and requiring no additional in-field modifications or assembly, except where specifically allowed by these Specifications. The enclosure is to be accurately dimensioned so as to be in compliance with the National Electrical Code (NEC), and the National Fire Protection Association (NFPA) for clearance of all specified items included therein, and all applicable fire codes for a structure and application of this type.

- B. Construction drawings, engineering blueprints, or other bid documents accompanying these Specifications which show switchgear, transfer switch(es), motor controllers(s), and/or other service or distribution equipment within the generator set enclosure must be considered complimentary to and not in lieu of this written Specification. Drawings submitted for approval shall reflect this fact clearly and any contradiction or omission shall be brought to the attention of the Director of Environmental Services.
- C. The enclosure shall be of sheet metal construction as designed and manufactured by the generator supplier. The design and construction shall be modular in that the side panels, doors, and louvers shall not exceed 36 inches in width and shall be a minimum thickness of 14 gauge for all component parts. The roof of the enclosure shall meet or exceed the minimum gauge requirements specified but, in addition, shall be strengthened in such a manner as to support the largest commercially available exhaust silencer recommended by the MANUFACTURER for this application.
1. Construction - All sheet metal used in the construction shall be primed and painted. This sequence of metal forming, and final assembly of the enclosure must be noted on the drawings submitted for approval and a factory certification of this manufacturing process shall accompany the "as-built" drawings provided to the OWNER. Walls and roof shall be constructed of 14 gauge steel.
 2. Attenuation – The enclosure will be designed to provide a noise emission rating of 76 decibels at a distance of 23 feet from any point on the generator. Utilize plenum if necessary to meet this requirement.
 3. Doors - All doors on the enclosure shall be strategically located in areas as to allow ease of maintenance on the generator set and allow good access to and visibility of instruments, controls, engine gauges, etc. The doors shall be fitted with bolt-on, stainless steel hinges constructed with stainless steel hinge pins of a diameter not less than 0.25-inch (1/4-inch). Each door shall be fitted with flush-mounted, adjustable, key-lock latches. Enclosure shall be rated for 110 MPH constant wind. Certified calculations shall be provided.
 4. Louvers - All louvers fixed and drainable with bird screen and shall be designed to the total engine/generator cooling air requirements used in this application. Maximum air velocity shall be 700 CFM. MANUFACTURER shall submit air flow calculations to engineer for review.
 5. Components All components of the enclosure shall be assembled utilizing 0.375-inch minimum stainless steel bolts, nuts, and lock washers. In addition, watertight neoprene flat washers shall be used on all roof bolts.
 6. The MANUFACTURER of the enclosure shall provide mounting brackets for the exhaust silencer specified. In addition, a tail pipe extension terminating in a horizontal plane and cut at a 45° angle to prevent the stainless steel, seamless flexible exhaust tube and all necessary bolts, flanges, and gaskets to mate with the engine and the exhaust silencer

shall be provided. The length of the flexible tubing shall be such that additional solid metal nipples or sections shall not be required to be provided as spacers between the engine exhaust port or the exhaust silencer.

7. All wiring to the switchgear from the generator shall be in conduits made from Rigid Metal, IMC, or liquid-tight material specifically manufactured for electrical use. All connections at the generator set shall be flexible, and all shall be provided and installed by enclosure manufacturer.
8. Oil and Water Drains - All necessary fittings, hoses, shut-off valves, etc., shall be provided by the MANUFACTURER of the enclosure to facilitate lube oil and water drain at the exterior of the enclosure. In addition, engines equipped with crank-case breather tubes shall have this tube terminate at the exterior of the enclosure directly under the radiator air discharge louver.
9. Enclosure - The enclosure shall be skintight construction to meet specific project requirements.
10. Under no circumstances shall the floor area or any of its parts be considered for cooling air intake or discharge requirements of the generator set or its associated equipment, nor shall its properties as a "heat-sink" or heat dissipating medium be utilized in any manner whatsoever in this application.
11. All items specified herein shall be supplied and prewired and/or pre installed including, but not limited to the following:
 - a. Rain dress for exhaust pipe and tail pipe extension. Rain dress shall prevent the entrance of rain and allow for the expansion and vibration of the exhaust piping without stress to the exhaust system. Rain dress shall be stainless steel and provided by the enclosure supplier.
 - b. Coordination between CONTRACTOR and Supplier is mandatory and the equipment Supplier's instructions will be adhered to without exception.

9.26 FUEL SYSTEM

- A. Base and Mounting - The generator set and enclosure shall be mounted and shipped to the jobsite on the formed steel sub-base provided by generator supplier. Provisions for crane unloading of the complete package shall be designed into the base of the unit.
- B. The base and enclosure assembly allow room within the package to mount and maintain the specified battery charger, engine starting batteries, racks, and cables, main line circuit breaker, and engine-generator control panel, and other items as specified or as shown on the drawings.
- C. The weight of the entire unit consisting of generator set, base, enclosure, and all other specified items including all liquids (i.e., fuel oil, lube oil, and cooling water) shall be calculated by the MANUFACTURER. The base of the unit shall be designed and manufactured as a heavy duty, formed steel construction with four (4) point lifting provision to support the calculated weight. Details and MANUFACTURER's certification of the base construction shall be included with

the drawings submitted for approval as well as all weight calculations.

- D. Base Tank (UL142) - The unit shall be equipped with a double wall in-base fuel tank and shall be supplied with a lockable, exterior located fill cap. The capacity (gallon) of the base tank shall permit operation of the generator for 3 days at 75 percent load. All necessary fuel and vent lines for proper engine performance shall be provided as well as a means to readily detect the fuel level in the tank without the use of a measuring stick.
- E. The fuel tank base dimensions shall be full size of the generator base and be formed from steel of a minimum metal thickness of 0.25-inch (1/4-inch) and shall be fitted with low fuel level and inner wall leak alarm contact for local and remote annunciation. The fuel tank height shall not exceed 30 inches.
- F. Filter/Separator-In addition to the standard fuel filters provided by the engine MANUFACTURER, there shall also be installed a primary fuel filter/water separator in the fuel inlet line to the engine. The filter shall be a Fleetguard, Racor, simplex or duplex Model 1000, as required for proper fuel flow. It shall be supplied and installed by the enclosure supplier.

9.27 EXHAUST SYSTEM

- A. Exhaust Silencer - A critical type, side inlet, end outlet, Nelson, Maxim M-51, or Silex JB silencer and a flexible stainless steel exhaust fitting properly sized shall be furnished and installed according to the MANUFACTURER's recommendation. Mounting shall be provided by the CONTRACTOR as required. The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth due to thermal expansion be imposed on the engine. Exhaust pipe size shall be sufficient to ensure that exhaust back pressure does not exceed the maximum limitations specified by the engine MANUFACTURER. So called "spiral" or truck mufflers are disallowed and will not be considered as equal to the industrial quality silencers specified above.
- B. The silencer shall be fitted with a tail pipe extension terminating at a 45° angle to prevent the entrance of rainwater. It shall also be fitted with an expanded metal bird screen.
- C. Rain Skirt - At the point where the exhaust pipe flexible tubing penetrates the roof of the enclosure, a suitable "rain skirt" and collar shall be provided by the MANUFACTURER. It shall be designed to prevent the entrance of rain and allow for expansion and vibration of the exhaust piping without chafing or stress to the exhaust system. This detail must appear on the drawings submitted for approval.

9.28 AUTOMATIC STARTING SYSTEM

- A. Starting Motor - A DC electric starting system with positive engagement shall be furnished. The motor voltage shall be 24 volts.
- B. Automatic Control - Fully automatic engine start-stop controls in the generator control panel shall be provided. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, overcrank, and loss of engine coolant. Alarms for approaching high water temperature and impending low oil pressure shall also be included. Controls shall include a 45-second single cranking cycle limit with lockout or a cyclic crank system with lockout and overcrank protection.

- C. Batteries - A lead-acid storage battery set of the heavy duty diesel starting type shall be provided. Battery voltage shall be 24 volts, and the battery set shall be rated no less than 225 ampere hours. Necessary cables and clamps shall be provided.
- D. Battery Tray - battery tray shall be provided for the batteries and shall conform to NEC 480-7(b). It shall be constructed of fiberglass and so treated as to be resistant to deterioration by battery electrolyte. Further, construction shall be such that any spillage or boil-over of battery electrolyte shall be contained within the tray to prevent a direct path to ground.
- E. Battery Charger - A current-limiting, automatic 24 volt DC charger shall be furnished to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input. AC input voltage shall be 120 volts, single phase. Amperage output shall be no less than ten (10) amperes. Charger shall be wall mounting type in NEMA 1 enclosure, and U.L. listed as an industrial control panel. The charger shall be as manufactured by LaMarche per NFPA 110 and U.L. 508. The charger shall be mounted and wired within the enclosure for the generator set by enclosure manufacturer.

9.29 MAIN LINE CIRCUIT BREAKER

- A. Type - Main line, molded case circuit breaker mounted upon and sized to the output of the generator shall be installed as a load circuit interrupting and protection device. It shall operate both manually for normal switching functions and automatically during overload and short circuit conditions. The breaker shall include ground fault sensing that will trip the breaker on ground fault conditions.
- B. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection. The circuit breaker shall meet standards established by Underwriters Laboratories, National Electric Manufacturers Association, and National Electrical Code.
- C. Generator exciter field circuit breakers do not meet the above electrical standards and are unacceptable for line protection.
- D. Circuit breaker shall have battery voltage operated shunt trip wired to safety shutdowns to open the breaker in the event of engine failure.
- E. Each circuit breaker shall be equipped with an auxiliary contact for remote annunciation of breaker position.
- F. The rating of each circuit breaker shall allow the starting of full generator SKVA.
- G. The circuit breaker enclosure, together with all specified circuit breakers, shall be designed for the specific generator set specified and be equipped with an isolated neutral conductor bus, rear copper stabs, or load cable lugs and be finish painted to match the generator set.

9.30 GENERATOR CONTROL PANEL

Generator set Control. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control

system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The generator set mounted control shall include the following features and functions:

A. Control Switches

1. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the RUN or Manual position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
2. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
3. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
4. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.

B. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:

1. Digital metering set, 0.5% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
2. The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
3. The control system shall log total number of operating hours, total kWH, and total control on hours, as well as total values since reset.

C. Generator Set Alarm and Status Display.

1. The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
2. The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for function, color, and control action (status, warning, or shutdown).
3. The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has

been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.

4. The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
5. The control shall include an amber common warning indication lamp.
6. The generator set control shall indicate the existence of the following alarm and shutdown conditions on an alphanumeric digital display panel:
 - low oil pressure (alarm)
 - low oil pressure (shutdown)
 - oil pressure sender failure (alarm)
 - low coolant temperature (alarm)
 - high coolant temperature (alarm)
 - high coolant temperature (shutdown)
 - high oil temperature (warning)
 - engine temperature sender failure (alarm)
 - low coolant level (alarm or shutdown--selectable)
 - fail to crank (shutdown)
 - fail to start/overcrank (shutdown)
 - overspeed (shutdown)
 - low DC voltage (alarm)
 - high DC voltage (alarm)
 - weak battery (alarm)
 - low fuel-daytank (alarm)
 - high AC voltage (shutdown)
 - low AC voltage (shutdown)
 - under frequency (shutdown)
 - over current (warning)
 - over current (shutdown)
 - short circuit (shutdown)
 - over load (alarm)
 - emergency stop (shutdown)
7. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.
8. The control shutdown fault conditions shall be configurable for fault bypass.

D. Engine Status Monitoring.

1. The following information shall be available from a digital status panel on the generator set control:
 - engine oil pressure (psi or kPA)
 - engine coolant temperature (degrees F or C)
 - engine oil temperature (degrees F or C)
 - engine speed (rpm)
 - number of hours of operation (hours)
 - number of start attempts

battery voltage (DC volts)

2. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

E. Engine Control Functions.

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
4. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
5. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

F. Alternator Control Functions:

1. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
2. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system

shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.

3. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
4. An AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds.

G. Other Control Functions

1. The generator set shall be provided with a network communication module to allow LonMark compliant communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network.
2. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25 VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

H. Control Interfaces for Remote Monitoring:

1. The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
2. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
3. A fused 10 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
4. The control shall be provided with a direct serial communication link for the LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.

9.31 AUTOMATIC LOAD TRANSFER SWITCH

- A. The rating of the automatic load transfer switch (ATS) shall be sized to the station main breaker rating. The ATS shall be service entrance rated if required by the NEC.

- B. The automatic transfer switch shall be mechanically held on both the emergency and the normal side, and rated for continuous duty in an unventilated enclosure. The switch shall be solid-state, electronically controlled, double throw with the main contacts rigidly and mechanically interlocked to ensure positive positioning of power switches. A manual operator must be provided to enable one (1) hand manual operation which, when utilized, can provide a neutral position for servicing operations.
- C. The automatic transfer switch shall be a single motor operated circuit breaker type with interpole barriers and arc chutes. So-called linear actuated or solenoid operated switches are approved only when manufactured by the Generator MANUFACTURER. All elements of the drive system must be replaceable from the front of the switch, and the power switching devices must be replaceable without removal of the connecting cables.
- D. The transfer switch shall be listed under U.L. 1008, in NEMA 4X stainless steel enclosure, as manufactured by Cummins, Russelectric, or Lakeshore Electric.
- E. Accessories - The automatic load transfer switch specified shall include the following accessories:
1. Full phase protection. Solid-state phase monitor shall be field adjustable, close differential type, with 85-100% pick-up and 75-98% drop-out. A single adjustment shall set all phases.
 2. Solid-state voltage and frequency monitor on generator output to prevent transfer prior to proper output parameters, adjustable 85-100% of generator rated voltage and frequency, with adjustable drop-out of 75-85% of pick-up setting.
 3. Adjustable, solid-state, 0.5 to 6 seconds time delay on engine starting to override momentary outages and nuisance voltage dips.
 4. Adjustable, solid-state, 2 to 30 minutes time delay on retransfer of load to normal.
 5. Adjustable, solid-state, 2 to 30 minutes cool-down timer wherein the generator set runs unloaded after retransfer to line.
 6. Motor load decay time delay, pneumatic type, adjustable for 1.5 to 15 seconds and operating on transfer to either source.
 7. Adjustable, solid-state, 0.5 seconds to 5 minutes time delay on transfer to emergency source after verification of emergency source voltage and frequency.
 8. Test switch to simulate normal power failure, heavy duty, oil tight, pushbutton type with momentary contacts and override circuitry to revert to normal power if emergency source should fail during test.
 9. Motor circuit disconnect switch.
 10. Three (3) pilot lights, to indicate the normal and emergency position of the transfer switch, and mode selector switch in "off" position.
 11. Engine starting contacts to provide for generator starting from each unit independent of the other.

12. One (1) auxiliary S.P.D.T. contact on emergency breaker and one (1) S.P.D.T. auxiliary contact on normal breaker.
13. Plant exerciser to start and run the generator set with or without load (in-field switchable) each 168 hours for a 30 minute interval.
14. Four (4) position mode selector switch marked "test", "auto", "off", and "engine start".
15. Equipment grounding lug.
16. Cable connection lugs, cu/al type for all conductors.
17. The ATS shall be either solid neutral or switched neutral design as required by the City.

9.3 EXECUTION

9.31 SERVICES

- A. Furnish the services of a competent and experienced MANUFACTURER'S field service technician who has complete knowledge of proper operation and maintenance of the equipment for a period of not less than two (2) days in two separate visits to inspect the installed equipment, supervise the initial test run, and to provide instructions to the plant personnel. The first visit will be for checking and inspecting the equipment after it is installed.
- B. At least one (1) of the two (2) days shall be allocated solely to the instruction of plant personnel in operation and maintenance of the equipment. This instruction period shall be scheduled at least ten days in advance with the OWNER and shall take place during plant start-up and acceptance by the OWNER.
- C. Three final copies of operation and maintenance manuals specified must be delivered to the Owner prior to scheduling the instruction period.

9.32 PAINTING

- A. The engine generator set and associated equipment shall be shop primed and finish coated in accordance with the MANUFACTURER's standard practice prior to shipment. An adequate supply of touch-up paint shall be supplied by the MANUFACTURER.

9.33 TESTING

- A. The engine-generator set shall be given the MANUFACTURER'S standard factory load test prior to shipment.
- B. Prior to final acceptance of the generator set, all equipment furnished under this Section shall be field tested per NFPA 110 to show it is free of any defects and the generator set can operate satisfactorily under full load test using resistance type load banks (brine tanks not acceptable). Test shall be for four (4) continuous hours. Any defects which become evident at this time shall be corrected before acceptance.
- C. An all-in-place static alignment check of all rotating components shall be made prior to first start-up, after unit is secured in place and all final connections are made.

9.34 SYSTEM SERVICE CONTRACT

- A. The supplier of the standby power system must provide a copy of and make available to the OWNER his standard service contract which, at the OWNER'S option, may be accepted or refused. This contract will accompany documents, drawings, catalog cuts, specification sheets, wiring or outline drawings, etc., submitted for approval to the Director of Environmental Services. The contract shall be for the complete services rendered over a period of one (1) year.

9.35 WARRANTY

- A. Equipment furnished under this Section shall be guaranteed against defective parts and workmanship under terms of the MANUFACTURER'S and dealer's warranty. But, in no event, shall it be for a period of less than five (5) years (comprehensive) from date of initial start-up of the system and shall include labor, parts and travel time for necessary repairs at the job site. Running hours shall not be a limiting factor for the system warranty either by the MANUFACTURER or the supplying dealer. Submittal data received without written warranties as specified will be rejected in their entirety.

(Reserved)